System, Method and Apparatus for Filling Containers

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Background of the Invention

Field of the Invention

The present invention relates generally to a system, method and apparatus for filling a container. More specifically, the present invention relates to a system, method and apparatus for vacuum-assisted filling of medicinal capsules with a precise dosage of dry powder pharmaceutical.

Related Art

In medicine, it is often desirable to administer various forms of medication to patients. A well known method of introducing medication into the human body is the oral ingestion of capsules. In another method, a patient may inhale certain medications through the nose or mouth. Inhalable medications come in numerous forms, including solids that are typically in the form of fine, dry powders. Specialized devices, such as inhalers, are typically provided to assist the patient in directing these fine powder medications through an airway and eventually into the lower respiratory tract. Various means for loading an inhaler with a proper dose of medication prior to use are known, including the use of capsules. For example, U.S. Patent No. 5,787,881 discloses an inhaler that is used with encapsulated dry powder medicaments. Such devices

require that capsules containing precise doses of medicament be available. The capsules are punctured and then inserted into the inhaler for inhalation of the medicament contained therein.

Countless other applications as well rely upon containers containing a specified amount of any of a number of materials. Many devices are known for filling such containers. However, each of these devices suffers certain drawbacks. U.S. Patent No. 5,743,069, for example, discloses a metering device for medical applications. In this device, metering members are used to mechanically meter dosages of pharmaceutical through a plurality of holes, and eventually into a plurality of capsules. However, such mechanical metering devices, which rely only on mechanical members and gravity to apportion a particular dose of powder from a larger supply thereof, may lead to inaccurate doses. Such inaccuracies can result from, among other things, air pockets or clumps of powder in the supply. In addition, medical applications relating to inhalable medicaments may involve the handling of very fine, low-density powders. It has been found that these powders are difficult to handle due to their tendency to aerosolize, or become airborne, at the slightest provocation. Thus, a device for the metering of such powders must be designed with this quality in mind.

U.S. Patent No. 5,826,633 discloses a powder filling apparatus for transferring an amount of powder to a receptacle. While the device addresses a problem of conglomerated powder through the use of a fluidizing means, the device is rather complex. Included are a variety of mechanical parts having relatively complicated interactions, and two motors requiring an external power supply. In addition, sources of vacuum and/or pressure are required.

Other devices, such as that disclosed in U.S. Patent No. 5,809,744, address a problem of preventing aerosolization of fine powders, also through application of a vacuum. However, the

device of U.S. Patent No. 5,809,744 draws a vacuum directly through a container, such as a filter bag, into which a material such as coffee is to be vacuum-packed. Because such a device utilizes a vacuum for packing, it is not readily suitable for metering an accurate amount of a material for delivery to a non-porous container. Such a device cannot fill containers such as medicinal capsules, through which a vacuum is not easily drawn. In addition, medical applications regularly require high accuracy on a far smaller scale of dosage than the disclosed larger-scale device could offer.

Still other devices, such as the material apportioning apparatus disclosed in U.S. Patent No. 4,671,430 and the powder filler disclosed in U.S. Patent 4,949,766, attempt to overcome the above problem by apportioning material in a different container from that which is intended to eventually contain the apportioned amount. However, such devices fail to provide the simplicity of design and ease of use sought by those in the art.

Other conventional capsule filling machines have other disadvantages. Typically such conventional machines are designed to pack large amounts of powders into capsules, and are not optimal for delicate porous powders. Additionally, such conventional machines require a large volume of powder (*e.g.*, greater than 500 ml) to prime the machine. Consequently, for some protein powders, in excess of $100,000 worth of powder is wasted just to prime the machine to fill one capsule.

Thus, there is a need in the art for an improved method and apparatus for filling containers with a precise dosage of dry powder. Specifically, what is needed is a method and apparatus capable of consistently delivering a precisely metered dose of dry powder medicament to a capsule. Preferably, such a device would further be simple in design and easy to use,

through either manual or computer-controlled operation. The device would also be adapted to handle the low-density fine powders often present in medical applications, and to vacuum pack such powders into relatively small and highly accurate doses for delivery to a container, using a small priming volume. The present invention, the description of which is fully set forth below, solves the need in the art for such an improved method and apparatus.

Summary of the Invention

The present invention relates to a system, method and apparatus for filling containers. In one aspect of the invention, a system for filling containers with powder is provided. The system includes a carousel. Disposed in the carousel is a container handling mechanism that includes a container block defining a container receptacle and a cap carrier defining a cap receptacle. The cap carrier is movable between a first carrier position and a second carrier position. The system further includes, adjacent the carousel, a dosing portion having a dosing plate defining a dosing hole. The dosing plate is movable between a first dosing position and a second dosing position, such that when the dosing plate is in the first dosing position, the dosing hole is positioned to receive a dose of powder. When the dosing plate is in the second dosing position, the dosing hole is positioned to dispense the dose of powder into the container receptacle.

Features and Advantages

One feature of the present invention is that it is well adapted for use with a variety of materials, including the very fine, low-density powders typically found in applications relating to inhalable medicaments.

Another advantageous feature of the present invention is that it is relatively simple in design and easy to use. Therefore, the device can be produced less expensively than more complex devices, and only very limited training is required prior to use.

The present invention also possesses the advantage that it consistently provides a high accuracy dosage of material to a container, as is important to a great number of applications. Further, the present invention requires a very small amount of powder for priming, typically less than 500 mg of powder.

Because the present invention carries the additional advantage that it can be manually operated, it can be readied for a single use in a short period of time. This renders it ideal for a laboratory environment where dosages are often required quickly and in limited quantities.

The present invention also advantageously can be computer-controlled and adapted for use in large-scale commercial filling facilities.

Further features and advantages will become apparent following review of the detailed description set forth below.

Brief Description of the Figures

The present invention is described with reference to the accompanying drawings. In the drawings, like reference numbers indicate identical or functionally similar elements.

FIG. 1 is a perspective view of one embodiment of a container filling apparatus of the present invention positioned to receive an empty container;

FIG. 2 is a perspective view of one embodiment of a container filling apparatus shown in **FIG. 1** positioned to fill a dosing hole;

FIG. 3 is an exploded view of one embodiment of a container filling apparatus of the present invention;

FIG. 4 is a cross-sectional view along line 4-4 of **FIG. 2** of one embodiment of a container filling apparatus of the present invention positioned to fill a dosing hole;

FIG. 5 is a cross-sectional view of one embodiment of a container filling apparatus of the present invention positioned to fill a container;

FIG. 6 is an aerial view of one embodiment of a container filling system of the present invention;

FIG. 7 is an aerial view of one embodiment of a cam disc of a container filling system of the present invention;

FIG. 8 is a side view of one embodiment of a cap carrier for a container filling system of the present invention; and

FIG. 9 is a side view of one embodiment of a container filling system of the present invention.

Detailed Description of the Preferred Embodiments

Overview

The present invention is an improved method and apparatus for providing a precise amount of powder to a container. As will be described in more detail below, an apparatus of the present invention is a container filling device that is easy to operate and has a relatively simple design. The container filler repeatedly delivers to a container a reliable dose of any of a variety of materials. The apparatus includes a dosing wheel for receiving a container to be filled and a

dosing plate for metering an amount of material to be delivered to the container. Metering preferably occurs in the dosing plate under force of a vacuum. Means are provided for ejecting the metered amount into the container.

The methods of the present invention use the container filling apparatus to fill a container with an accurate amount of a material. As will be discussed in greater detail below, a user utilizes the method of the present invention by placing a container in the dosing wheel. The dosing wheel is rotated into a position below a dosing hole that houses the predetermined amount of material that has been metered in a dosing plate. The metered dose is then ejected into the container, which can be removed and used as desired.

Filling Apparatus and Associated Methods and System of the Present Invention

An exemplary embodiment of the present invention will now be described. While the above discussion has often related to a method and apparatus for filling a medicinal capsule with a powder medicament, it should be recognized that the present invention is equally applicable to any of a variety of fields in which it is desired to introduce a precise amount of a material to a container. The applicability of the present invention is therefore not limited to the medical field.

Referring to Figures 1 and 2, an embodiment of a container filling apparatus of the present invention is illustrated as filler **11**. The filler **11** comprises a dosing wheel **15** disposed within and movably coupled to a base member **12**; a plate guide **13** coupled to the base member **12**; a dosing plate **14** disposed within and slidably coupled to the plate guide **13**; a receiving plate **18** disposed within the plate guide **13**; and an ejector member **20** disposed in the receiving plate **18**. The receiving plate **18** has a receiving hole **28** (see Figure 3) formed therein for receiving a

powder hopper **19**. The dosing plate **14** has a dosing hole **23** (see Figure 3) formed therein for receiving a metered amount, that is a 'dose,' of powder or other desired material from the powder hopper **19**. The dosing plate **14** is slidable between a filling position, as seen in Figure 2, and an emptying position, shown in Figure 1. The filling and emptying positions will be described in more detail below with respect to Figure 3. The dimensions of the dosing hole **23** will determine the size of the dose of powder received by the dosing hole **23**. The size of the dose of powder that will be deposited into a container by the filler **11** will be the size of the dose receivable by the dosing hole **23** or a whole number multiple thereof, since the container may be filled by a single or multiple doses from the dosing hole **23** as desired. When it is desired to deposit an amount of powder differing from the amount receivable by a single or a whole number multiple of doses by the dosing hole **23** of the current dosing plate **14**, the dosing plate **14** may be interchanged with another dosing plate having a dosing hole of different dimensions.

Dosing wheel **15** is preferably rotatably coupled to base member **12**. It should be readily apparent to one skilled in the art that the present invention is not limited to a dosing wheel of a round or circular shape as depicted in the figures, nor is it limited to a dosing wheel rotatably coupled to the base member. For example, in an alternate embodiment of the present invention, the dosing wheel is configured as a straight (nonround) piece movable in a linear fashion.

The dosing wheel **15** has a container receptacle **17** formed therein for receiving a container to be filled by the filler **11**. Preferably with the assistance of a handle **16**, the dosing wheel **15** is rotatable between a container loading position, as illustrated in Figure 1, and a powder receiving position, shown by Figure 2. As illustrated, the dosing wheel **15** is preferably rotatable independent of the sliding position of the dosing plate **14** and vice versa. In an alternate

embodiment of the present invention, the apparatus is configured, through the use of a cam system for example, so that as the dosing wheel **15** is rotated from the container loading position to the powder receiving position and back, the dosing plate **14** automatically slides from the filling position to the emptying position and back. In such an alternate embodiment, the dosing plate **14** is movably coupled to the dosing wheel **15**.

In the embodiment shown in Figures 1 and 2, the apparatus of the present invention is configured for manual operation for quick and easy use. However, as will be readily apparent to one skilled in the art, operation of the container filler could also be automated through use of a processor, computer, or computer-control system for applications where a greater number of containers need to be filled. An automated embodiment is further discussed below.

Referring now to Figures 3-5, an internal arrangement of the filler **11** of the present invention may be more readily appreciated. In Figure 3, the dosing plate **14** is illustrated in the filling position and the dosing wheel **15** is shown in the container loading position. When the dosing plate **14** is in the filling position, the dosing hole **23** will be in registry with the powder hopper **19** and will therefore be in a position to receive a dose of powder from the powder hopper **19**, as may also be seen in Figure 4. Also in registry with the powder hopper **19** and the dosing hole **23** will be the base member central bore **12a** defined by the base member **12**, and the dosing wheel central bore **15a** defined by the dosing wheel **15**, as illustrated by the central bore line **30**. Sliding the dosing plate **14** in a channel **29** defined in the plate guide **13** to the emptying position will cause the dosing hole **23** defined in the dosing plate **14** to be in the position illustrated in phantom by hole **23a**. Rotating the dosing wheel **15** to the powder receiving position will cause the container receptacle **17** defined in the dosing wheel **15** to be in the position illustrated by

phantom hole **17a**. In this position, referring again to Figure 3, the dosing hole **23** and container receptacle **17** will be in registry. Such registry is shown by the container filling line **31**, and can also be seen in Figure 5. Once in this position, a dose of powder residing in the dosing hole **23** of the dosing plate **14** can be deposited into a container previously loaded into the container receptacle **17**.

Details of a filling operation will now be more fully described. When it is desired to add a metered dose of a material to a container, an amount of the material, such as a powder **26** (best seen in Figures 4 and 5), greater than a size of the metered dose, is added to the powder hopper **19**. As desired, the powder **26** may be added to the powder hopper **19** before, but is preferably added after, the powder hopper **19** is inserted into the receiving hole **28**. The dosing plate **14** is moved into the filling position. A dose of the powder **26** may fall into the dosing hole **23** under the force of gravity alone, but is preferably assisted by a vacuum (not shown) to ensure that the powder is well packed in the dosing hole **23**, forming a powder slug. The vacuum is connected to a vacuum connection **25**, which is provided with a filter **24**.

In operation, the vacuum connection **25** and the filter **24** are disposed within the base member central bore **12a** of the base member **12** and within the dosing wheel central bore **15a** of the dosing wheel **15**. The filter **24** preferably abuts a surface of the dosing plate **14** to form a relatively airtight seal. When the vacuum is operated, the filter **24** allows air to flow through the filter **24** and dosing hole **23** but prevents powder from passing beyond the plane of the surface of the dosing plate **14** against which the filter **24** is abutted. Thus, depending on a particulate size of a powder being used, filter paper of any suitable mesh size may be used. In one embodiment, the use of .2 or .5 micron paper, for example, is contemplated. When air is drawn through the

vacuum, air will also be drawn through the dosing hole **23**, the receiving hole **28** and the powder hopper **19**. This forcefully draws a dose of the powder **26** from the powder hopper **19** into the dosing hole **23** and against the filter **24** to form the powder slug.

Meanwhile, a container is added to the container receptacle **17** of the dosing wheel **15** while the dosing wheel **15** is in the container loading position. In medical applications, the container will typically be a capsule formed of a material such as gelatin or hydroxypropylmethyl cellulose (HPMC). Once the container has been loaded, the dosing wheel **15** is rotated into the powder receiving position. Following formation of the powder slug in the dosing hole **23**, the dosing plate **14** is moved from the filling position to the emptying position, placing the powder slug in position above the container in container receptacle **17**. The powder slug may then fall into the container under the force of gravity, or may be assisted through the use of the ejector member **20**. The ejector member **20** is disposed in the receiving plate **18**, and is in fluid communication with an ejector hole **27** formed therein.

In one embodiment, the ejector member **20** comprises a flexible membrane **22** coupled to the receiving plate **18** by a ring member **21**. However, it should be readily apparent to one skilled in the art that other types of ejector members could be used, such as an ejector pin, a valve mechanism for delivering a puff of air, etc. Actuation of the ejector member **20**, such as by manual pressure, causes an increase in air pressure in the ejector hole **27**, between the flexible membrane **22** and the powder slug, forcing the powder slug from the dosing hole **23** into the container previously placed in the container receptacle **17**. The container has now been supplied with a precisely metered dose of the powder **26**. One or more additional doses of powder may now be added to the same container by repeating the above steps, or the dosing wheel **15** may be

returned to the capsule loading position and the container removed from the container receptacle **17**.

Referring next to Figures 6-9, an embodiment of an automated container filling system of the present invention will be described. A container filler **60** includes a carousel **62** preferably rotatable about a carousel central bore **65** between 5 carousel positions A, B, C, D and E, as illustrated in Figure 6. As would be readily apparent to one skilled in the art, varying numbers of positions may be used, and the present invention is not limited to five positions. The carousel **62** has disposed therein a plurality of container handling mechanisms **70**. Each container handling mechanism **70** includes a container block **71** having formed therein a container receptacle **72** for receiving one or more containers (not shown) to be filled; a cap receptacle **73** (shown in phantom); a cap carrier **74**; and a spring assembly **76**. Each cap carrier **74** is slidably disposed in a carrier channel **78**. Each cap carrier **74** further includes a vacuum opening **75**, as will be discussed in greater detail below. While in this embodiment, the number of container handling mechanisms **70** as illustrated corresponds to the number of carousel positions, the number of container handling mechanisms **70** may be greater or lesser as desired.

Referring next to Figure 7, a cam disc **80** is illustrated. As will be discussed below with reference to Figure 9, the cam disc **80** is preferably positioned beneath the carousel **62** for controlling a position of each cap carrier **74** within each carrier channel **78** as the carousel **62** rotates. As is further illustrated in Figures 8 and 9, each cap carrier **74** includes a cam bearing **77** that travels about a cam channel **82** formed in the cam disc **80** as the carousel **62** rotates. A cam center **85** of the cam disc **80** preferably corresponds with the central bore **65** of the carousel **62**, with each center preferably corresponding to a center axis **105**. As will be appreciated by one

skilled in the art, forces applied by an inner wall **83** of the cam channel **82** to each cam bearing **77** will translate into lateral movement of each cap carrier **74** within each carrier channel **78** as the carousel **62** rotates with respect to the cam disc **80**. An opposing lateral force applied by each spring assembly **76** will keep each cam bearing **77** in contact with the inner wall **83** as the carousel **62** rotates. Alternatively, the spring assemblies **76** may be omitted in reliance instead on the inner and outer walls **83** and **84** of the cam channel **82** to keep each cap carrier **74** in a proper position. It would be readily apparent to one skilled in the art that the cap carrier could alternatively be activated by an electrical, mechanical, or pneumatic activator, and the like. Thus, as the carousel **62** rotates, each cap carrier **74** will reciprocate in each associated carrier channel **78** between a position proximal to each container block **71** and a position distal from each container block **71**. Furthermore, while as illustrated, the container blocks **71** and the cap carriers **74** move together on the carousel **62**, they may alternatively be designed to move independently. For example, the container blocks **71** may be disposed on a carousel independent of a carousel on which the cap carriers **74** are disposed. In another embodiment, the container blocks may be formed in stationary portions adjacent a carousel housing the cap carriers **74**, etc.

As can also be seen in Figure 8, each cap carrier **74** further includes a cap receptacle **73** in fluid communication with a vacuum tube **79**, each of which is preferably coupled to each cap carrier **74** at each vacuum opening **75** (see Figure 6).

Operation of the automated container filler **60** will now be described. While multiple steps of a container filling process may occur simultaneously at any of the plurality of container handling mechanisms **70**, the process will, for clarity, be discussed with respect to a single container handling mechanism **70** as it moves through the illustrated carousel positions A, B, C,

D, and E. Referring again to Figure 6, position A represents a container loading position. In this position, the cap carrier **74** is, by operation of the cam disc **80** on the cam bearing **77**, in a position in the carrier channel **78** that leaves it clear of the container receptacle **72**. This allows the container receptacle **72** of the container handling mechanism to be provided, from an empty container hopper **90**, with a container (not shown) to be filled. Loading of the container will be further discussed below. In one embodiment, the container to be filled is a capsule commonly used for medicament delivery.

As the carousel **62** rotates, the container handling mechanism **70** being discussed rotates to position B, which is a container separating position. Position B is optional, but is preferred in embodiments in which the containers to be filled have caps. As the carousel rotates to position B, the cap carrier **74** slides into position over the container block **71** such that the cap receptacle **73** (see Figure 8) is disposed above the container receptacle **72**. Under the power of a vacuum applied via the vacuum tube **79**, the cap of the container to be filled is lifted into the cap receptacle **73** where it is held temporarily. The cap may be held by continued application of the vacuum or by other means as desired.

As the carousel **62** continues to rotate, the cap carrier **74** slides in a direction away from the container block **71** to return to a position leaving it clear of the container receptacle **72**. This allows for filling of the container in the container filling position C. Adjacent the carousel **62** at position C is a dosing portion **100** having a dosing hole **102** and a dosing plate **104**. In a manner analogous to that discussed above with respect to manually operated embodiments, the dosing hole **102** of the dosing plate **104** is filled with a material, such as a powder, to be supplied from a powder hopper **106** to the container to be filled. Once the dose has been formed in the dosing

hole **102**, the dosing plate **104** will slide to position the dosing hole **102** above the container receptacle **72**, and thus above the container to be filled. A sliding position of the dosing plate **104** is preferably controlled by an air piston, but may alternatively be controlled by any suitable means. The dose may then be deposited into the container in any desired manner, numerous of which have been discussed above.

The container having been filled, the carousel **62** rotates to place the container handling mechanism **70** into position D, a container closing position. As illustrated, the cap receptacle **73** of the cap carrier **74** is again positioned above the container receptacle **72** of the container block **71**. The cap will then be released from the cap receptacle **73** such that the cap is returned to the container. Additional mechanisms may assist in properly mating the cap with the container if desired.

The carousel **62** will next rotate the container handling mechanism **70** to a container ejecting position E. Here, the filled and capped container is ejected into a full container bin **110**.

Figure 9 illustrates an orientation of the empty container hopper **90** and the dosing portion **100** with respect to the container filler **60** in one embodiment of the present invention. As shown, the container filler system **120** may also include a container rectifier **92** for ensuring that containers from the empty container hopper **90** enter each container receptacle **72** in a proper orientation. Also illustrated is a motor **94** for controlling a rotation of the carousel **62**. Preferably, the motor **94** is a stepper motor, and is operated under the control of a programmable logic controller (PLC). The PLC further preferably coordinates rotation of the carousel **62** with insertion of empty containers from the empty container hopper **90**, operation of the dosing portion **100**, and ejection of full containers into the full container bin **110**.

Example

Table 1 below is provided to further illustrate the present invention, but is not intended to limit the invention in any manner. Table 1 shows results from a series of trials using a system, method and apparatus of the present invention. The first row represents a powder used. The final two rows respectively represent a mass median aerodynamic diameter (MMAD) and mass median geometric diameter (MMGD) for each powder. As can be seen, the first four columns of data reflect results obtained for a single type of powder **a**. Dosing of powder **a** was performed at each of four different dosing densities obtained by varying a strength of a vacuum used. Relative standard deviations (RSD) of a mean dose of an indicated sample size from a target fill weight are shown for each trial series. Thus, as can be seen, low RSDs may be obtained through practice of the present invention even for very low MMAD powders.

Powder	a	a	a	a	b	c	d
Target Fill Wt. (mg)	3	3	22	N/A[1]	10	5	5
Population Size	1170	1170	290	30	200	12	12
Sample Size	60	36	15	30	14	6	6
Mean Dose (mg)	2.7	3.1	21.3	3.7	10.3	5.0	5.0
Plate #	1	1	1-	0	7	5	5
Plate Volume (cc)	0.015	0.015	0.130	0.015	0.090	0.060	0.060
Dosing Density (g/cc)	0.18	0.20	0.16	0.25	0.11	0.08	0.08
RSD (%)	6.1	4.9	4.6	4.3	4.1	3.7	7.8
MMAD	3.1	3.1	3.1	3.1	N/A[1]	2.5	2.3
MMGD	6.7	6.7	6.7	6.7	N/A[1]	13.1	6.4

TABLE 1

[1] N/A — data not available.

Conclusion

While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only, and not limitation. For example, the present invention is not limited to the physical arrangements or dimensions illustrated or described. Nor is the present invention limited to any particular design or materials of construction, or to any particular types of powder or powder containers. As such, the breadth and scope of the present invention should not be limited to any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.